Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT

A98O0214

IN-FLIGHT MAIN ROTOR BLADE SEPARATION

AG-ROTORS INC.

BELL 47-G2 (HELICOPTER) C-FODS

WINDSOR, ONTARIO 3NM E

13 AUGUST 1998

Canada

Aviation Investigation Report

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Summary

The Bell 47-G2 helicopter, serial number 1281, was engaged in an aerial crop spraying operation when one of the main rotor blades separated from the rotor hub in flight. The pilot could not control the helicopter; it struck the ground and burst into flames in the field the pilot was spraying. The pilot, with serious injuries, was rescued from the burning helicopter by persons passing by on a road adjacent to the accident site. The accident occurred at 0720 eastern daylight time, during daylight hours, at an elevation of 622 feet above sea level.

Ce rapport est également disponible en français.

Other Factual Information

There were a few clouds at 3 000 feet above ground level (agl) and 15 000 feet agl with a broken cloud layer at 28 000 feet agl. Visibility was 15 statute miles with shallow fog. The wind was from 330 degrees true at 3 knots and the temperature and dew point were 16 and 15 degrees Celsius, respectively.

The pilot was certified and qualified for the flight in accordance with existing regulations, and was a licenced aircraft maintenance engineer (AME).[1]

The company purchased the helicopter in June 1998. Before operating it, a 100-hour inspection was completed by a Transport Canada (TC)-approved maintenance organization (AMO), and TC carried out an inspection before approving company operation of the helicopter. The company had operated it a total of eight hours before the accident.

On the morning of the accident, the pilot transported the helicopter by trailer from his base at Chatham, Ontario, to the farm where he planned to carry out the crop spray operation. After arriving at the farm, the pilot carried out a daily inspection of the helicopter, flew the helicopter from the trailer over the selected field for a circuit in order to inspect the field, landed, then loaded the helicopter with fuel and chemical for the spray operation. The pilot completed one swath of spray application, and as he pulled up to commence a 180-degree turn, he heard a loud bang at about 100 feet agl. The helicopter rolled left, pitched uncontrollably nose-up then nose-down, and then descended nose-down until it struck the ground on a 120-degree magnetic heading. A post-crash fire ensued, consuming most of the helicopter engine and cabin area. One of the two main rotor blades, identified as the blue blade[2] (part number 47-110-120-50, serial number P9551), was recovered 400 feet south of the main wreckage. The blue blade separated from the helicopter at the inboard end in the internal threaded region of the blade grip (part number 47-120-135-5, serial number A100). A section of the failed blade grip remained attached to the blade; the section that did not remain attached was not recovered. The other blade, identified as the yellow blade, still attached to the rotor head and main rotor transmission, was recovered 100 feet north of the main wreckage. The main rotor head, mast and rotor transmission separated, intact from the helicopter, before ground impact. The helicopter tail boom and tail rotor remained intact and were recovered with the main wreckage.

Figure 1 - Failed Blade Grip

1 AME licence did not include helicopter type aircraft.

2 Main rotor blade tips are painted different colours for ease of blade identification.

The main rotor head, mast and transmission assembly, with the yellow blade attached, as well as the blue blade with the portion of the failed grip attached, were transported to the TSB Engineering Laboratory for examination. Heavy deposits of grease were present in and adjacent to the bore of the failed blue blade grip. The blue blade grip was removed from the blade for further examination. Examination of the components of the blue blade grip attached to the main rotor blade showed no pre-separation deficiencies and both the main rotor radial outboard and duplex bearings were found to be in good condition. Removal of the yellow blade from the grip and disassembly of the yellow blade grip from the main rotor hub revealed the same presence of heavy deposits of grease in and adjacent to the bore of the blade grip, and the bearings were in good condition. It was noted that a quantity of water was dislodged upon disassembly of the yellow blade grip from the main rotor hub.

The yellow blade grip (Part Number 47-120-135-5, Serial Number A68) was examined for cracks. The fluorescent penetrant inspection method found no cracks; however, when examined by the eddy current procedure, a number of cracks were identified in the threaded area of the grip, the largest measured 0.31 inch in length.

The blade grips were manufactured in March 1986. Aircraft records show that both main rotor blade grips were installed on the helicopter on 08 July 1993 and had been in service for a total of 207.8 hours. Records do not show the main rotor blade grips ever being removed from the helicopter from that time to the time of the occurrence. Records also show that the grips were purchased from the helicopter manufacturer and had been shipped to the helicopter operator on 06 July 1993. The helicopter log book entries show that both main rotor blade grips were new from the helicopter manufacturer at the time they were installed on the helicopter. The aircraft log book entries made by the maintenance engineer who installed the blade grips and a shipping document from the helicopter manufacturer were the only historical documentation on the main rotor blade grips that the TSB was able to obtain.

Records show that this is the second in-flight separation of a civil-registered Bell model 47-G2 helicopter main rotor blade as a result of a fatigue failure of the main rotor blade grip in the area of the threaded inboard end. The previous failure, in May 1985, involved a blade grip (Part Number 47-120-252-7, Serial Number JI-9288) that had accumulated a total of 5 768 hours in service since new. The May 1985 accident resulted in the issuance of Alert Service Bulletin (ASB) 47-85-12, on 17 December 1985, that introduced a factory mandated in-service life of 1 200 hours for Bell model 47 helicopter blade grips of the type that failed and others, including the blade grip on the present occurrence (Part Number 47-120-135-5). The ASB was subsequently reinforced by Airworthiness Directive (AD) 86-06-08 R1, effective 10 July 1987, which required a flourescent dye penetrant inspection of the internal threads at 1 200 hours or immediately if the grip had already exceeded that time and every 300 hours thereafter. Ultimately, Canadian AD CF-88-08 was issued, effective 31 May 1988, mandating that Bell model 47-G2 helicopter main rotor blade grips (Part Number 47-120-135) be subjected to an eddy current crack detection

inspection at 1 200 hours in-service time since new, and every 300 hours thereafter until a maximum in-service life of 2 500 hours, at which time the blade grips must be retired from service.

The blade grips from the blue blade, the yellow blade, and a blade grip from the manufacturer's inventory, serial number A155, were examined. The materials used to manufacture the blue and yellow blade grips were within the manufacturer's specifications. The threads in both the serial number A100 and A68 grips were found to conform with the manufacturer's specification. The thread was originally designed to the American National (NS) form, a specification which has been superceded by the American National Standards Institute's standard for Unified Screw Threads (UN). Qualitatively, however, it was observed that the root radii were much smaller than those for the manufacturer's spare, Serial Number A155. However, the UN specification for fine internal threads does not specify any minimum curvature radius for the root radius which may vary according to the sharpness of the tool used to cut the thread.

Extensive pitting was found on the surface of both the bottom of the thread roots and the adjacent surfaces of the threads. Fatigue crack origins were found to be coincident with the stress concentrations provided by the individual pits. The presence of pitting was also confirmed by the micro-sections; although, due to the thinness of the anodized layers and difficulties in retaining the edges during specimen preparation, it was less clear whether the pitting had preceded the anodizing step of the component manufacture. Some metallographic evidence would suggest that this was indeed so, and more recent work by the manufacturer would tend to confirm this conclusion.

The following external markings were noted. The part number for the blue blade grip was displayed in raised forged numbers "47-120-135-5" on the trailing edge surface of the grip at the base of the two blade attachment tangs. A second identical part number ink-stamped marking and inspector's stamp were noted on the control horn flange trailing edge surface. On the leading edge side of the grip where the forge markings are usually located, there was a scribed serial number "A100" and a scribed number "37340". The original forge markings had been removed by a surface blending operation leaving only a partial number "- - 14". In comparison, the yellow blade trailing edge surface of the grip displayed the same raised forged part number in the same location, except that the number "47" and the number "5" had been scribed into the surface presumably following prior removal of the raised forged numbers. A circle with the letters "bh" inside appeared on this same surface of the grip. On the leading edge side of the grip, a scribed serial number "A68" and a scribed number "37340" appeared, along with a raised forged map of the State of Texas accompanied by the letters "AJ" and the numeral "3". The raised forged letters "WPC" appeared within the outline of the map of Texas. The raised forged number "2014" appeared, identifying a 2014 alloy forging manufactured by W. Pat Crow Space Corp. (WPC). Both grips showed several regions where the anodized surface had been removed by some form of blending operation and had not been replaced or otherwise protected. In contrast, the grip from the manufacturer's inventory showed a scribed serial

number “155” and only raised forged markings for part and forging identifiers with no surface refinishing markings. This blade grip would appear to be the closest of the three grips to the manufacturer’s process planning documentation.

Analysis

The helicopter became uncontrollable and descended out of control to the ground when one of the main rotor blades separated in flight.

The blue main rotor blade separated in flight as a result of fatigue cracking initiated in the rotor blade grip's internal threads at the last complete outboard-most thread. Failure occurred instantaneously as the crack grew to critical dimensions under normal service loading. Cracks found in the yellow main rotor blade grip were similar yet less advanced.

The threads in both the Serial Number A100 and A68 grips were found to conform with the standard UN fine thread form, although the root radii were much smaller than those for an exemplar spare. The sharp root radii coupled with extensive pitting found on both blade grips provide one plausible explanation for the premature fatigue failure of the blue grip. Both sharp root radii and pitting are known stress concentrators which facilitate fatigue crack initiation.

No abnormal installation or operational conditions were identified with the helicopter that would explain the in-flight fatigue generated failure of the blue main rotor blade grip, or the cracks found in the yellow main rotor blade grip, well before the components first prescribed mandatory inspection cycle.

Notwithstanding the inconsistent part markings and surface alterations displayed on the main rotor blade grips, there is no reason to suggest that the blade grips installed on the helicopter were not authentic parts supplied by the helicopter manufacturer.

The following Engineering Laboratory report was completed:

LP 100/98 - *Main Rotor Blade Separation*.

This report is available upon request from the Transportation Safety Board of Canada.

Findings as to Causes and Contributing Factors

1. One of the helicopter main rotor blades separated from the helicopter in flight when the blade grip failed due to fatigue cracking initiated within the thread area of the blade grip.

2. The reason for the rotor blade grip's fatigue failure could not be determined.

3. The blade grip failed 992 hours before the first in-service required inspection cycle.

Other Findings

1. The pilot was certified and qualified for the flight in accordance with existing regulations.

2. Records indicate that the helicopter was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

3. Similar fatigue cracking was found in the other main rotor blade grip.

Safety Action

Action Taken

Current inspection requirements for the main rotor blade grips of Bell 47 helicopters may not adequately reduce the risk of structural failure and loss of life. Therefore, the TSB sent an Aviation Safety Advisory to Transport Canada suggesting that they determine whether any Canadian registered Bell 47 helicopters are equipped with main rotor blade grips belonging to the affected batch lots. The TSB suggested the possible need for a fatigue crack examination at an interval that provides a greater margin of safety than the existing inspection cycle.

An Aviation Safety Advisory was also sent to the National Transportation Safety Board suggesting that they advise the Federal Aviation Administration about the circumstances of this accident with a view to:

1. Identify and inspect the Bell 47 helicopter main rotor blade grips from the same batch lots as on the accident helicopter; and

2. Modify Alert Service Bulletin 47-85-12, Rev A, and U.S. Airworthiness Directive 86-06-08 R1 to include eddy current testing.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 22 June 2000.